PB84-170844

Liners for Waste Impoundments and Disposal Facilities

(U.S.) Municipal Environmental Research Lab.
Cincinnati, OH

1981

U.S. Department of Commerce
National Technical Information Service
NTIS

PB84-170844

EPA-600/D-81-249
1981

LINERS FOR WASTE IMPOUNDMENTS AND DISPOSAL FACILITIES

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U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/D-81-249		PB84-170844

4. TITLE AND SUBTITLE	5. REPORT DATE
LINERS FOR WASTE IMPOUNDMENTS AND DISPOSAL FACILITIES	1981
	6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Robert E. Landreth	

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
USEPA/MERL/SHWRD 26 West St. Clair Street Cincinnati, OH 45268	11. CONTRACT/GRANT NO.

12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Municipal Environmental Research Laboratory--Cin.,OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268	Technical Paper
	14. SPONSORING AGENCY CODE EPA/600/14

15. SUPPLEMENTARY NOTES

16. ABSTRACT

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17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	11
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

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LINERS FOR WASTE IMPOUNDMENTS AND DISPOSAL FACILITIES

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ABSTRACT

An overview is presented of the current technology related to liners of waste disposal and impoundment facilities. Information is summarized on the characteristics, selection, performance, and installation of liners for various disposal situations. Some cost estimates are also included. Basic guidelines are given for the design and construction of lined waste facilities, and suggestions are made for preparing construction and material specifications.

INTRODUCTION

Lining waste storage and disposal impoundments with manmade materials of low permeability has been demonstrated as a feasible method of preventing leachate and waste liquid components from leaving the impoundment and polluting the groundwater. Such liners can also be used to prevent the migration of methane and other gases from the disposal site. A wide variety of materials are available as candidates for specific impoundments.

This paper presents an overview of current knowledge and technology related to liners of waste disposal and impoundment facilities. Information discussed here is presented in detail in the U.S. Environmental Protection Agency (EPA) manual entitled "Lining of Waste Impoundment and Disposal Facilities."(1)

IMPORTANCE OF WASTE IDENTIFICATION

Proper identification of wastes to be contained in lined impoundments is essential if liner failure and pollution of ground and surface waters are to be avoided. The service life and durability of liners depend greatly on the fluids with which they come into contact. Wastes must be identified so that a compatible liner can be selected and the impoundment can be adequately designed.

The general categories of waste disposed of in lined impoundments are municipal solid waste (MSW), solid and liquid hazardous wastes, and other non-radioactive special wastes (e.g., power plant and mine wastes). Constitutents of these wastes cannot attack liners or migrate through the ground unless they are dissolved in fluid. Because these fluids are complex in composition, they are difficult to contain and can have combined effects on many liners. Thus variations in waste composition must be minimized at a given disposal site.

LINING MATERIALS

Liners for waste impoundments are of several types: Soil and clay liners, admixed or formed in place liners (such as asphalt or concrete), prefabricated, flexible polymeric membranes, spray-on linings, soil sealants

(made of various chemicals or latexes), and chemical adsorptive liners that remove pollutants from the liquid waste as it passes through.

Soils and Clays

Clayey soils should be considered first for a waste confinement liner because of their general availability. Failure of such a liner should not occur if environmental conditions have been analyzed and understood, and if the design complies with all environmental requirements.

Admixed Liners

A variety of admixed or formed-in place liners have been used for impounding water: asphalt, concrete, soil cement, and soil asphalt, all of which are hard-surface materials. Experience is limited, however, with the use of admixes to line disposal facilities and impoundments. These materials are undergoing exposure testing in two EPA research projects.(2, 3)

Hydraulic asphalt concretes are used as liners for hydraulic structures and waste disposal sites. They are similar to highway paving asphalt concrete, but they are a harder grade.

Soil cement is a low-strength Portland cement concrete with greater stability than natural soil. The permeability of this mixture varies with the type of soil, but it can be reduced with the use of coatings such as epoxy asphalt and epoxy coal tar. Unfortunately, it tends to crack and shrink on drying.

Soil asphalt is a mixture of available onsite (usually low plasticity) and liquid asphalt. Permeability of soil asphalt after compaction varies with the percent of compaction and asphalt.

Flexible Polymeric Membranes

Prefabricated liners based on sheeting of polymeric materials are of particular interest for the lining of waste storage and diposal impoundments. As a group, these materials exhibit extremely low permeability. They have found substantial use in water impoundments and are being used more frequently in the lining of disposal facilities.

The polymeric materials most frequently used in liners are polyvinyl chloride (PVC), chlorosulfonated polyethylene (CSPE), chlorinated polyethylene (CPE), butyl rubber (IIR), ethylene propylene rubber (EPDM), neoprene, high- and low-density polyethylene (HDPE and LDPE). Most liners are based on individual polymers, but blending introduces the possibility of meeting many performance specifications. Liner performance in the field cannot presently be defined by laboratory tests, however.

Spray-on Linings

Liners for disposal impoundments can be formed in the field by spraying onto a prepared surface a liquid that solidifies to form a continuous

membrane. Such liners have been used in water control and impoundment. Most experience with this type of liner has been with air-blown asphalt, but a number of new materials are becoming available. Problems encountered with spray-on liners include pinholes and adverse reactions with many wastes.

Soil Sealants

Permeability of some soils can be significantly reduced by the application of various chemicals or latexes. They may be waterborne, mixed in place, spray-applied, or injected below the soil surface.(4) Types of sealants include resinous polymer/diesel fuel mixtures, petroleum-based emulsions, powdered polymers that form gels, and monovalent cationic salt.(5)

Chemical Absorptive Liners

Chemical absorptive liners function primarily by removing pollutants from the liquid waste as it passes through the liner mass. Chan et al. (6) have tested several clays and minerals, acidic and basic fly ash, bottom ash, activated alumina, and activated charcoal as potential chemical liners for activated charcoal as potential chemical liners for calcium fluoride, metal finishing, and petroleum sludges. Further testing and evaluation are necessary.

EFFECTS OF WASTES ON LINING MATERIALS

As mentioned earlier, it is the fluids generated within the waste that pose the pollution and liner durability problems. In fact, the pollutants are generally not the aggressive agents in the waste liquids. All waste consitutents must be considered when assessing a liner material for a given application; in addition, the chemical composition of the liner must be considered.

Effects of Waste Fluids on Soil Liners

Permeability is the essential property to be considered in the case of a soil liner. As soon as the soil solution is changed to a foreign solution (waste leachate), the soil tends to develop new characteristics that affect soil flow properties.

The major failure mechanisms for soil liners include dissolution of clay, volume changes in soil, piping, altered permeability of compacted soil, and side slope instability. Other failure mechanisms also exist, but they are poorly understood and require further research.

Effects of Fluids on Flexible Polymeric and Admixed Liners

Polymeric Liners--Two EPA projects have been undertaken to assess the effects of various wastes on a wide spectrum of potential polymeric membrane liners.(1) The first project dealt with exposure of liner materials to sanitary landfill leachate, and the second concerned exposure of similar types of liners to hazardous wastes.

Results from the project showed that swelling of membrane liners in leachate is significantly higher than that obtained in water, in spite of dissolved inorganic constitutents in the leachate. Results of the second test revealed that most polymeric materials tend to swell and change in some properties when exposed to fluids. Swelling usually has adverse effects that make the product unserviceable: Softening, loss of tensile and mechanical strength, loss of elongation, increased permeability and potential of creep, and greater susceptibility to polymer degradation.

Admixed Liners--As part of the two liner research programs described above, soils and admixed liner materials were also exposed to sanitary landfill leachate and hazardous waste. After 56 months of exposure to leachate, the asphalt concrete and soil asphalt liners lost drastically in their compressive strengths, but they maintained their impermeability to leachate. The asphalt binder (which normally hardens on aging in air) became softer, indicating possible absorption of organic components from the leachate.

The soil cement liner lost some of its compressive strength, but it hardened considerably during exposure and cored like a Portland cement concrete. It became more impermeable during exposure. Some leaks occurred in the paving asphalt and soil asphalt liners, but these were probably due to inhomogenities in the admix materials.

Five types of admixed materials were exposed to hazardous wastes with varied results. Many waste/liner combinations resulted in seepage and soil contamination, and complete failure occurred in some cases. Other liners, such as soil cement, yielded no seepage of any of the wastes tested, even after long exposure.

Conclusion--Though information on specific waste/liner compatibilities may be sufficient in some cases to choose an adequate liner without testing, a compatibility test is generally recommended before a decision is made.

DESIGN AND CONSTRUCTION OF LINED WASTE FACILITIES

Basic Planning Considerations

The success of a waste impoundment facility can be greatly influenced by its site. Many factors must be considered during site planning--native soils and subgrades, drainage, wind direction and velocity, ambient temperatures, vegetation, and proximity to populated areas, for example.

Impoundment design is usually controlled by the type of waste to be impounded and by the type of facility the impoundment will serve. Included in a good plan must be user information (name, addresses, etc., of owners, operators, design engineers), meteorological data (temperature, wind, precipitation), process data (waste characteristics and composition), and facility needs and characteristics (capacity, life, flow, equipment, regulating agencies, and monitoring requirements).

Soil- and Clay-Lined Facilities

The designer of a soil liner must provide flexible specifications because of soil variability and the scale of operation. Inspection of the adequacy of the work is vital, both by visual observation and testing. A field laboratory should exist, or access to a qualified laboratory should be available.

Evidence must show that (a) the design density has been achieved, and (b) at these density specifications, the soil has the designed flow properties. All operational specifications (depth of soil liner, soil moisture content, etc.) must be rigorously observed by the constructing team.

When construction begins, the earthwork is usually done by a general engineering/construction contractor. If free water develops and persists at the impoundment base, an artificial base may have to be constructed. All vegetation should be removed from the site. Slopes should be constructed by normal techniques. An underdrain system may be necessary where there is a high groundwater table or source of water infiltration. Soil compaction is essential in the construction of all types of liners.

Admix-Lined Facilities

Soil cement liners can be made from standard or plastic soil cement mixes using road paving methods and equipment. This type of liner must be sealed with bituminuous liquids and emulsions.

Details for constructing, placing, and curing cement concrete liners may be obtained from the Bureau of Reclamation's Concrete Manual (7) and from consulting engineers in the field.

Asphalt concrete for hydraulic structures is similar to paving asphalt, but it contains higher percentages of mineral filler and asphalt. The subgrade should be smoothed by rollers after compacting the top six inches, and a soil sterilant should be applied to prevent weed growth. A prime coat of hot liquid asphalt is then applied to the surface and allowed to cure before paving. The asphalt concrete liner should be compacted as soon after spreading as possible. All joints should be staggered to insure strength and low permeability.

Prefabricated asphalt panels require careful planning and workmanship for proper installation. The subgrade is excavated, smoothed and rolled, and soil is applied if necessary. Panels are then butted together or overlapped. Bonding is done with hot or cold asphalt mastic adhesives.

Flexible Membrane Liner Installations

Much current information about flexible liner installation and equipment is based on a recently completed study by Shultz (8). Flexible liner installations generally have similar planning, design, and construction components. One of the most important components is the subgrade. Equally critical to a good project is the proper installation of the liner over the subgrade. Experienced installers should be depended on for this step to

assure adequate compliance with project plans and specifications. A comprehensive quality control program is also required during design and construction of flexible liners to assure that the materials used will meet facility requirements and that workmanship conforms to specifications.

Spray-on Liners

A basic problem in the placement of spray-on liners is to make them pinhole-free. These liners require a more carefully prepared subgrade than others, and they may require sand or soil padding for proper membrane support. Another problem in application is the rapid cooling and hardening property of these liners.

Soil Sealants

Asphalt emulsions may be injected with special equipment six inches below the surface to form a continuous membrane about 1/2-inch thick.

Chemisorptive Liners

Chemisorptive liners include soil sealants, liquids, or powders (which are applied similarly to spray-on liners) and pozzolanic or cement-like materials (which are installed and constructed following procedures similar to those used for asphalt, concrete or cement).

MANAGEMENT, OPERATION, AND MAINTENANCE OF LINED WASTE FACILITIES

Proper management of a lined waste disposal facility is essential to achieving good facility performance and maximum service life of the liners. Lined facilities must be managed so as to (a) protect the impoundment and liner integrity, (b) monitor liner system performance, and (c) monitor the condition of the liner.

Operating Procedures

Standard handbooks and manuals should be followed on operation of waste impoundments (9, 10, 11, 12, 13). For lined sites, additional information should be provided on the specific types of construction and materials that were used for the specific disposal facility. Detailed information on all components of the liner system should be made available to the operating personnel.

Monitoring Systems

Monitoring systems must be developed for incoming waste, impoundment performance, liner condition, earthwork conditions, and appurtenances.

Regular onsite inspections should be made of the impoundment, and preventive maintenance should be performed. Vandalism and unauthorized dumping must be carefully monitored and curtailed.

Management of Leachate

Leachate volume of landfills is primarily a function of the amount of water that flows through the refuse (precipitation is a key factor). When infiltration of water exceeds the combined effects of runoff, evapotranspiration, and soil moisture storage, leachate will be produced (1). Leachate removal is accomplished by draining it in a collection system of perforated pipes installed in gravel-filled trenches and discharging it to sumps from which the leachate is pumped.

COSTS FOR LINED WASTE FACILITES

Cost may be an important factor in the ultimate choice of a liner material for a given site, but other cost items are affected by the type of liner material selected. The 1977 installed costs for polymeric membranes ranged from \$1.10/yd^2 for PE liners to \$6.75/yd^2 for neoprene, with most values ranging from \$3.00 to \$3.50. The 1973 installed costs for admixes, soil, and asphalt liners varied from \$0.75/yd^2 for bentonite soil to \$4.20/yd^2 for asphalt concrete.

SELECTING A LINER AND PREPARING SPECIFICATIONS

Designers of lined waste disposal facilities must select liners that meet a wide range of requirements. In making the decision, the designer should consider the liner as part of a many-layered system of different permeabilities and characteristics. Many factors may be considered, but the following requirements must be met by any liner selected:

a. Compatibility and durability of the liner with regard to the waste.
b. Low permeability to the waste over time.
c. Reliability and low risk of failure.
d. Relative ease of installation, quality control, repair, and maintenance.

After selecting the liner material and incorporating it into the design of the waste disposal facility, the designer must prepare the necessary specifications and drawings for the bid package and for use in construction.

Construction specifications should include specific instructions for the following:

- Site preparation, embankment, and other earthwork.
- Subgrade preparation.
- Liner construction for soils, admixes and spray-on materials.
- Liner installation, particularly field seaming.
- Quality control/quality assurance.
- Drainage and gas venting systems.
- Appurtenances and penetrations.

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